"On the 'Blaze-currents' of the Gall Bladder of the Frog." By ALICE M. WALLER. Communicated by AUGUSTUS D. WALLER, M.D., F.R.S. Received December 1, 1904,—Read January 26, 1905.

(From the Physiological Research Laboratory of the University of London.)

This investigation is a continuation of Dr. Waller's work on the electrical responses to stimulation exhibited by animal and vegetable living tissues, which responses he has designated "Blaze-currents."*

I have employed the method already described by him at length, in the University Series of Lectures entitled "Signs of Life."†

After examining many tissues and organs from the frog and cat, my attention was directed particularly to the liver of the frog, which one would naturally expect to display signs of activity; not obtaining very large responses from the liver, I tested the gall bladder, and to my surprise, observed large electrical variations which occur regularly and without fail, and may be noticed as long as 24 hours *post mortem rancæ.*

The frog is killed; the liver and gall bladder are taken out and placed on a glass plate; unpolarisable electrodes are applied to the liver or gall bladder. The electrodes are always previously tested, and are made so that they give no response to electrical stimulus.

The liver is found to give antidrome currents except when the electrodes are placed one on the surface and one at the hilum; in this case the responsive current runs from the surface to hilum.

Excitation by Single Break Induction Shocks from Berne Coil.

Liver (March 9).

Strength of excitation.	Response.	
Coil at 5000 + gave	− 0·0005 volt.	Liver placed between electrodes with under surface upwards
− „	+ 0·0003 „	
10000 − „	+ 0·0010 „	
+ „	− 0·0013 „	

* 'Phil. Trans.,' B, vol. 194, p. 184, December, 1900; 'Roy. Soc. Proc.,' vol. 68, p. 79, January, 1901.

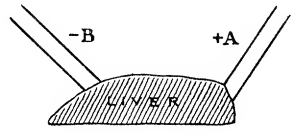
† 'Signs of Life,' published by John Murray, 1903, for the University of London.

Liver (March 24).

Strength of excitation.	Response.		Electrodes.
5000 –	+0·0010		10000 + = 0·0001
,, +	−0·0009		,, – = 0·0001
10000 +	−0·0013	+0·0002	
–	+0·0022		

Liver.

5000 –	+0·0047	Response surface to hilum	Electrodes placed on surface and hilum
+	+0·0053		
1 hour later—			
10000 +	−0·0047	+0·0002	
–	+0·0047	−0·0003	



Liver (May 7).

5000 + =	−0·0008	+0·0004	
–	+0·0005		
+	−0·0009	+	
10000 +	−0·0018	+0·0004	Remaining and slowly subsiding.
–	+0·0018		

The gall bladder invariably gives an antidrome "blaze" or response to excitation; it is an instance of the equivocal blaze current, in the contrary direction to the exciting current, described by Waller in vol. 68, p. 79, 'Proc. Roy. Soc.' Weak stimulus elicits one antidrome blaze; to stronger stimulus the response may be triphasic; antidrome, homodrome, antidrome. The first and antidrome response is a large effect and soon over, the galvanometer spot flies off and quickly returns to zero and beyond, indicating the second and homodrome effect, which is a prolonged change lasting about two minutes and slowly subsiding, the second effect is often larger than the first.

The blaze is a local effect, as shown in experiment on March 22, where it is abolished by strong tetanus at one spot, but found to persist in other parts on turning the bladder round.

The blaze is abolished by boiling the gall bladder or by subjecting it to strong chloroform vapour, or by tetanus.

Gall Bladder. Experiment of March 3, 1904.

Excitation by Single Break Induction Shocks from Berne Coil.

Strength of excitation.			Response.	
Coil at	1000	– gave	+ 0·0012 volt.	Gall bladder had a piece of liver
	,,	+ ,,	– 0·0037	under it
	,,	+ ,,	– 0·0080	Gall bladder placed freely between
	,,	– ,,	+ 0·0060	electrodes
Shunt $\frac{1}{5}$	,,	– ,,	+ 0·0073	
	,,	+ ,,	– 0·0080	
	,,	+ ,,	– 0·0060	
	,,	+ ,,	– 0·0020	
	,,	– ,,	+ 0·0012	
	5000	– ,,	+ 0·0040	
	,,	+ ,,	– off	+ off
Shunt $\frac{1}{10}$	,,	+ ,,	– 0·0123	+ 0·0030
Shunt $\frac{1}{50}$	10000	+ ,,	– 0·0133	
Shunt $\frac{1}{10}$	,,	– ,,	+ 0·0033	– 0·0025 +
	,,	– ,,	+ off	– off
	,,	– ,,	+ 0·0033	– 0·0046
	,,	+ ,,	– 0·0250	
	1000	+ ,,	– 0·0003	
	,,	– ,,	Nil	
	5000	– ,,	+ 0·0020	
	,,	+ ,,	– 0·0030	
Shunt $\frac{1}{5}$	,,	+ ,,	– 0·0025	
	,,	– ,,	+ 0·0015	
	10000	– ,,	+ 0·0030	
	,,	+ ,,	– 0·0025	
	,,	– ,,	+ 0·0025	
Shunt 1	10000	+ ,,	– 0·0022	
		– ,,	+ 0·0015	
		– ,,	+ 0·0011	

Gall Bladder (March 5, 1904).

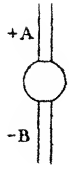
Coil at.			Response.	Electrodes. N.C. + 0·0006.		
S.s.	1000	+ =	– 0·0008			
		– =	+ off	10000 –	=	+ 0·0002
Shunt $\frac{1}{10}$	,,	– =	+ 0·0100	,, +	=	– 0·0001
		– =	+ 0·0110			
		+ =	– 0·0020			

Coil at.		Response.		Electrodes.
1000 +	=	− 0·0020		
−	=	+ 0·0090		
5000 +	=	− 0·0090	+ 0·0080	
−	=	+ 0·0020	− 0·0300	+ 0·0060
−		+ 0·0060	− 0·0080	+ 0·0020
-		+ 0·0080	− 0·0030	
−		+ 0·0080	− sinking	
+		− 0·0040	+ 0·0080	
10000 −		+ 0·0180	− 0·0060	+ off
+		− 0·0272		
−		+ 0·0172	− 0·0081	+ 0·0030
−		+ 0·0200	− 0·0054	+ 0·0030
+		− 0·0127	+ 0·0054	− 0·0020
+		− 0·0114		
−		+ 0·0085		
−		+ 0·0071	− 0·0015	
5000 +		− 0·0071		
−		+ 0·0035	− 0·0014	
+		− 0·0064		
−		+ 0·0050	− 0·0014	
1000 −		+ 0.0007		
+		− 0·0009		

(Boiled)

1000 +	nil
−	nil
5000 −	+ 0·0002
+	− 0·0001
10000 +	− 0·0003
−	+ 0·0004

Another Gall Bladder (March 5).



1000 +	=	− 0·0005
−	=	+ 0·0018
5000 −	=	+ 0·0091
+	=	− 0·0075
10000 +	=	− 0·0087
−	=	+ 0·0081
5000 −		+ 0·0054
+		− 0·0040

The responses are not so lasting as they were

Gall bladder put under $CHCl_3$ in a glass chamber of about 1 inch cubic space. $CHCl_3$ on cotton wool attached to top of chamber by modelling wax. After $\frac{1}{4}$ hour strong chloroform vapour—

5000 − = nil
+ = nil

Gall Bladder (March 9).

Coil at.		Response.	
S.s. 1000 +	=	− 0·0005	
,, −	=	+ 0·0019	
5000 +	=	−	
,, −	=	+ 0·0061	
,, +	=	− 0·0063	
10000 +	=	− 0·0076	+ 0·0005
,, −	=	+ 0·0076	− 0·0005
5000 −		+ 0·0005	− 0·0002
,, +		− 0·0009	
10000 +		− 0·0015	
,, −		+ 0·0012	

Gall Bladder (March 9).

Coil at.		
S.s. 1000 +	− 0·0012	
,, −	+ 0·0020	
5000 −	+ 0·0060	
,, +	− 0·0023	
1000 −	+ 0·0076	
,, +	− 0·0069	
5000 +	− 0·1110	+ after effect then − 0·0020
,, −	+ 0·0110	− 0·0040
10000 −	+ 0·0080	Interval then − 0·0020
,, +	− 0·0060	+ 0·0003

After chloroform—

5000 + nil
10000 + − 0·0001
,, − nil.

Envelope examined gave no effects and looked dried up; no sign of blood-vessel usually seen.

A. *Gall Bladder* (March 10, 1904).

Coil at.		Response.		
S.s. 1000 +	=	− 0·0040		
−		+ 0·0100		
5000 −		+ 0·0140	− 0·0100	
+		− 0·0200	+ 0·0020	
10000 +		− 0·0280	+ 0·0010	− 0·0040
−		+ 0·0260	− 0·0060	

Gall Bladder (March 22).

		Response.	Electrodes.
N.C. (accidental or normal current) = + 0·0004 volt			10000 + = − 0·00004
S.s. 1000 +	=	nil	− = + 0·00004
,, −	=	+ 0·0002	
5000 +	=	− 0·0020	+ 0·0002
,, −	=	+ 0·0016	− 0·0015 Returning slowly
10000 −	=	+ 0·0050	Returning slowly, then − 0·0009
,, +	=	− 0·0040	+ 0·0002
,, +	=	− 0·0040	
½ min. tet.			
Coil at 10000 +	=	+ 0·0015	

After strong tetanus.

S.s. 5000 −	=	+ 0·0000	
10000 −	=	+ 0·0003	
,, +	=	− 0·0001	
5000 +	=	nil	
Tet. ,, +	=	+ 0·0003	
S.s. 10000 −	=	+ 0·0001	

The bladder was turned round in order to expose two fresh surfaces to the electrodes.

N.C. + 0·0015, decreasing to 0.

Coil at.			
S.s. 5000 −	=	+ 0·0007	− 0·0002
10000 −	=	+ 0·0010	− 0·0001
+	=	− 0·0008	
5000 +	=	− 0·0004	

1 minute tetanus

Tetanus at 10000 +			
S.s. 10000 +	=	− 0·0001	
,, −	=	+ 0·0000	

Turned round again to spots previously tetanised.

Coil at.	
S.s. 10000 +	nil
„ −	nil

Gall Bladder (March 24).

	Coil at.	Response.		
S.s.	1000 +	= − 0·0022		
	−	= + 0·0020	− 0·0007	+ 0·0014 Very slowly subsiding
Shunt $\frac{1}{5}$	−	+ 0·0013	− 0·0003	+ 0·0011
	+	− 0·0038		
	5000 +	− 0·0077	+ 0·0011	Remaining, then falling to − 0·0011
Comp. + 0·0006	−	+ 0·0061	− 0·0022	+ 0·0011
Comp. + 0·0008	10000 −	+ 0·0072	− 0·0022	
„ + 0·0015	+	− 0·0088	+ 0·0005	Back to zero, and falling − 0·0005
	After 1 hour interval.			
	10000 +	− 0·0069		
	−	+ 0·0033		

Large Gall Bladder (August 3).

Coil at.		Response.		
S.s. 1000 +	=	− 0·0024	+ 0·0019	Remaining and falling to − 0·0010
„ −	=	+ 0·0012	− 0·0027	Returning rapidly to + 0·0005 subsiding slowly
„ −	=	+ 0·0010	− 0·0031	+ 0·0002 subsiding slowly
„ +	=	− off. Remaining and subsiding in 2 minutes		
„ −	=	+ 0·0027	− 0·0006	+ 0·0019

Gall Bladder (August 11).

S.s. 1000 +	=	− 0·0009	+ 0·0016	Remaining for about 2 minutes − 0·0005
−	=	+ 0·0083		
+	=	− 0·0033	+ 0·0050	− 0·0017
5000 +	=	− 0·0150	+ 0·0033	− 0·0017
−	=	+ 0·0133	− 0·0006	
10000 −	=	+ 0·0070	− 0·0033	Remaining
+	=	− 0·0083	+ 0·0033	„

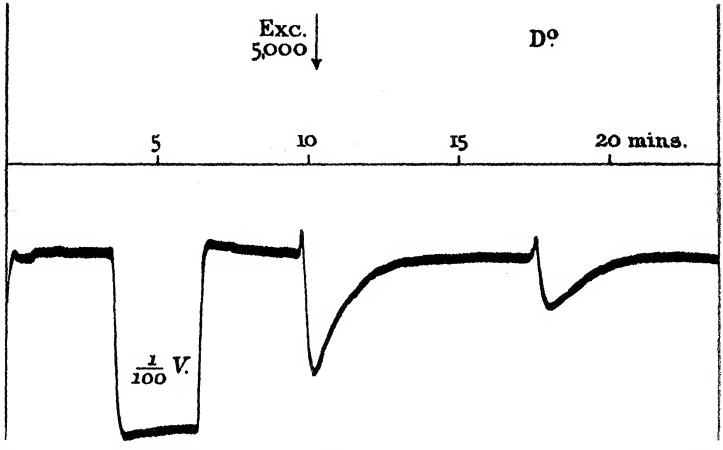
Gall Bladder.

1000 + = − 0·0010
− nil
+ = − 0·0016
− = nil
5000 − = + off scale, then − off remaining and returning in 2 minutes
− = + 0·0108 − 0·0022
+ = − 0·0108 Slowly returning
− = + 0·0100

September 29.

1000 − = + 0·0011 − 0·0003
+ = − 0·0021
5000 + = − 0·0117 + 0·0017
− = + 0·0112 − 0·0008 + 0·0003

Fig. 1.



Photograph of Galvanometer Record of the Blaze-currents of Gall Bladder. Deviation of $\frac{1}{100}$ volt.

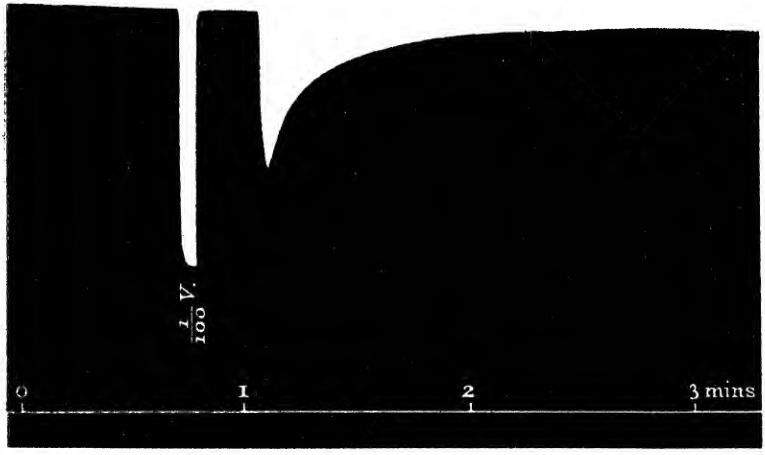
Coil at 5000 + = − 0·0010 + 0·0064 volt
,, + − 0·0010 + 0·0028

In this case the blaze is diphasic, the second phase being larger and more lasting than the first, which is very characteristic.

At Dr. Alcock's suggestion I syringed out the gall bladder and filled it with NaCl solution, 0·6 per cent., and then tested it; the effects still occurred in the some order and almost same magnitude, showing that they were due to action in the enveloping gall bladder itself and not to the bile contents. (See experiments of May 7.)

I am indebted to Dr. Alcock for sections of the gall bladder of the frog and cat which he kindly prepared for me, and to Mr. Gordon Webb for enlarged micro-photographs of the same. The gall bladder of

Fig. 2.

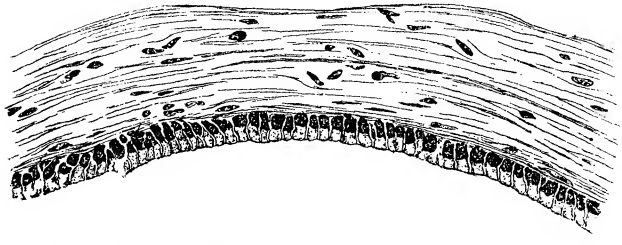


Photograph of Electrometer Record of the Blaze Currents of Gall Bladder. Deviation of $\frac{1}{100}$ volt.

Coil at 5000 + = −0·0060 volt.

the frog consists of a single layer of columnar nucleated cells, and layers of smooth muscle fibres with connective tissue. The bladder of the frog is quite round and the layer of columnar cells lies flat, whereas in the cat the bladder is a long-shaped body with the layer of columnar cells thrown into folds, and outside the smooth muscle

Fig. 3.



Section of Frog's Gall Bladder, showing Inner Mucous Layer of Columnar Epithelium, and Outer Layers of Smooth Muscle Fibres. (Enlarged 2500 diameters and Photographed by Mr. H. Gordon Webb, Assistant Demonstrator of Anatomy in St. George's Hospital Medical School.)

fibres is a layer of connective tissue. The simplicity of structure in the frog may perhaps account for the large electrical changes observed; in the cat's gall bladder there is little or no response to stimulus.

Gall Bladder Washed out with Salt Solution and then Tested (May 7).

			Response in voltage.	
Coil at S.s.	5000 −	=	+0·0020	−0·0010
	+	=	−0·0003	
	10000 +	=	−0·0010	
	−	=	+0·0030	−0·0005
	−	=	+0·0005	−0·0001

The Gall Bladder syringed out and filled with Salt Solution.

Coil at	10000 +	=	− off	
Shunt $\frac{1}{5}$	+	=	−0·0060	
	−	=	+0·0050	
	5000 −	=	+0·0020	−0·0005
	+	=	−0·0022	+0·0001

The bladder is now cut open and spread on electrode with mucous inner surface to A, the upper electrode.

Coil at	10000 +	=	−
	−	=	+
	−	=	+
	+	=	−

Tested by Waller's ABC method,* the response at both poles is found to be antidrome. In some cases the response is diphasic at the anode, and diphasic at the kathode, see Experiment of May 7th.

By this method the local reactions at anode or kathode can be examined; C is an indifferent point at which an electrode is placed which has not been excited. By means of a switch key the excitation is made through electrodes at points A and B. Any initial current through AC is compensated if it is wished to examine A, and any initial current through BC is compensated if it is wished to examine B. It sometimes happens that AC and BC require compensation in the same direction and of the same magnitude, and then it is permissible to switch the key on to either one or the other, and examine the direction of the current; in the following experiments dotted lines signify that this has been done.

* On "Skin Currents," 'Roy. Soc. Proc.,' vol. 69, p. 181.

Gall Bladder tested by Dr Waller's ABC Method.

Excitation through BA and lead-off through BC or AC.

B C A

S.s. 1000 ←——— +0·0142

Remaining and gradually diminishing.

——→ ←—— −0·0019

1000 ——→ ←—— −0·0062

←——— ——→ +0·0028

Compensation current.

5000 ←———

BC = −0·0007 ——→ +0·0075

CA = −0·0008 ·····→ +0·0091

·····→ +0·0094

On changing key to CA the deflection of galv. is further +0·0016 returning to BC sends it further +.

——→ ←—— − off, and back to +0·0010

——→ ←—— −0·0075

5000 − ←——— ——→ +0·0150

5000 + ——→ ←—— −0·0075

·····→ +0·0020

←····· −0·0006

Changing to CA sends it +2°, and BC is found to be −6° without shunt.

5000 − ←——— ——→ +0·0150

·····→ +0·0110

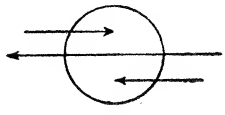
Changing to BC lessens the + effect by 4° (shunt $\frac{1}{5}$) = 0·0040

5000 + ——→ ←—— −0·0045 Followed by +0·0025

BC = −0·0010 5000 ——→
CA = −0·0010 ←—— −0·0043 Changing to
⋯→ +0·0033 CA = +3°

BC = −0·0014 10000+ ——→
CA = −0·0011 ←—— −0·0032
⋯→ +0·0003
⋯→ +0·0003

After the effect −3° (0·0032) has passed off, I unshunt and find that with no shunt BC = +3° CA = the same 3°+



10000 ←——
—→ +0·0028
⋯← −0·0090

Changing to CA suddenly, the same deflection persists, but soon falls to −8°. Changing to BC brings the spot to 0

10000 ←——
CA = +0·0020 —→ +0·0015

BC = −0·0005 10000 ——→
CA = +0·0020 ←—— −0·0015
⋯←

On taking off the compensation, +0·0020, and changing to BC, spot returns to 0 and goes −4°

10000 ——→
CA = +0·0018 ←—— 0·0015

Another Gall Bladder.

	5000 −	+ off	− off
Shunt $\frac{1}{5}$	„ −	+0·0078	−0·0005
	„ +	−0·0042	+0·0052
	10000 +	−0·0063	+0·0050

(First effect quickly over, second effect slowly subsiding.)

− +0·0078 −0·0011

	B	C	A	Response	
Coil at 5000	←——				
	—→			+0·0050	−0·0011
		←—		−0·0011	
	←——				
	——→			+ off	−0·0017

	B C A	Response.	
Coil at 5000	←		
	→	+ off	− 0·0009
	←		
	→	+ 0·0017	No after effect
	→		
	←	0·0020	Slowly subsiding

1½ hour later—

5000 +	=	− off	+ off
Shunt ⅕	+	− 0·0016	+ 0·0042
	−	+ 0·0068	

5000	←		
	→	+ 0·0002	− 0·0004
− 0·0008	←		
	→		
After 0 changed to BC terminals − 0·0009	←	− 0·0015 and return to 0	

BC effect − 0·0009 remains and subsides slowly; the CA effect − 0·0015 disappeared quickly, for the spot returned quickly to 0

	→	
− off, slowly subsiding to + 4	←	
	→	+ 0·0004

Slight + effect on changing to CA, but − effect on changing back to BC; the − effect at BC has now subsided and is going +

	←	
	→	+ off − 0·0010
	←	− 0·0005 after the BC has returned to 0
	←	
	→	+ 0·0036 − 0·0011
	—	0
10000	→	
	←	− 0·0031
	→	+ 0·0005
	←	− 0·0005
	→	
	←	− 0·0002
	—	0

Gall Bladder (May 7).

5000 + − 0·0030

− + 0·0030

Kathode Anode

(1) ←——— ——→ + 0·0030

(2) ←——— ——→ + 0·0023

Anode Kathode

(3) ——→ ←—— − 0·0012

(4) ——→ ←—— − 0·0008

(5) ——→ ←—— − 0·0008

Kathode

(6) ←——— ←—— − 0·0006

Kathode

(7) ←——— ←—— − 0·0004

(8) ←——— ——→ + 0·0013

(9) ←——— ——→ + 0·0007 − 0·0002

+ 0·0025 ——→

(10) ←———

− 0·0001 ←——

←—— − 0·0030

(11) ←——— ——→ + 0·0006 − 0·0001

——→ + 0·0030

Kathode

(12) ←———

− 0·0001 ←——

←—— − 0·0040

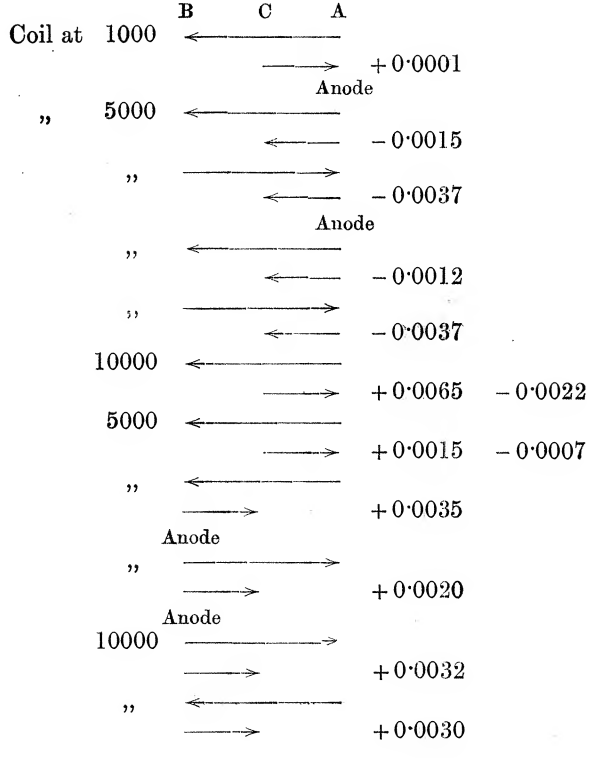
In experiment, May 7, some of the responses from the kathode are homodrome, *e.g.*, excitations (6), (7) and (12); in the last there is found to be a homodrome response from the anode which also appears slightly in (11) after the usual antidrome.

Gall Bladder Attached to Liver.

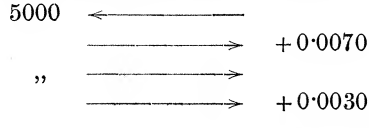
Compensation.					
	Coil at	5000 −	+ 0·0094	− 0·0011	+ 0·0033
+ 0·0006		+	− 0·0100	+ 0·0011	
		+	− 0·0036		
		−	+ 0·0054	− 0·0038	

Compensation.			
+0·0005	10000 –	+0·0100	–0·0038
,,	+	–0·0161	
+0·0003	+	–0·0130	
–0·0002	–	+0·0061	–0·0034

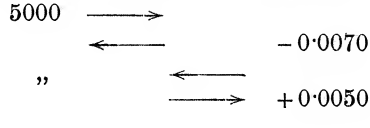
Excitation through BA, lead off from A or B, and an indifferent point, C.



Excitation through BA, and lead off through BA.



Excitation through BC, and lead off through BC, ditto CA.



In this experiment some of the responses from the anode are homodrome. A single shock with coil at 5000 – gives – 0·0015 from the anode. The stronger excitation with coil at 10000 calls out the antidrome response + 0·0065 and then the homodrome response from the anode – 0·0022, and then the weaker excitation at 5000 gives the same responses in a lesser degree + 0·0015 – 0·0007.

Same Gall Bladder separated from Liver.

	B	C	A	Response.	
Coil at 5000	⟶	⟶	⟶		
	⟵	⟵	⟵	– 0·0050	+ 0·0040
	⟶	⟶	⟶		
	⟵	⟵	⟵	– 0·0020	+ 0·0025
		⟶			
		⟵		– 0·0007	+ 0·0015

Envelope

5000 +	=	– 0·0004	+ 0·0003
–	=	+ 0·0006	
10000 –	=	+ 0·0008	
+	=	– 0·0006	

Liver (April 30).

5000 –	=	+ 0·0010
+		– 0·0020
10000 +	=	– 0·0036
–	=	+ 0·0026

Gall Bladder alone.

5000 –	+ 0·0250	Then sinks to	– 0·0080
+	– 0·0100	+ 0·0050	Sinking back to – 0·0040
–	+ 0·0250	– 0·0100	
+	– 0·0050	+ 0·0060	

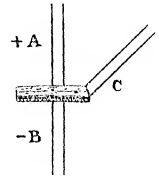
Slice of envelope gave no response.
Contents of gall bladder gave no response.

It is a very easy matter to demonstrate the blaze-currents on the frog's gall-bladder, because the organ can be separated and placed between electrodes without injury; but it is a difficult matter to cut out a piece of the round bladder and place it on electrodes without injuring the delicate tissue. It is necessary, however, to do this in order to study separately the mucous and serous surfaces. I found the most convenient procedure was to cut the bladder across with scissors, the bladder collapses, but the piece cut off rests on the blade

of the scissor and can be gently drawn by a brush on to the soft china clay electrode, so that the inner epithelial surface, which laid on the scissor blade, now rests on the electrode; the other electrode can be now applied to the outer smooth muscle fibre surface. If the piece of bladder is sufficiently large a third electrode can be applied to its edge and the effect of stimulation at both surfaces studied by Waller's ABC method.

In the experiments of March 10 the blaze was directed from the mucous to the serous surface and was of considerable magnitude, but the sixth excitation elicited a response in the antidrome direction before giving one from mucous to serous. In experiment of July 21 there is also blaze from mucous to serous.

The following figure gives a plan of the position of the electrodes and tissue in the ABC experiments. Unless otherwise stated in the following tables the + sign signifies from mucous to serous and − signifies from serous to mucous.



A. *Envelope of Bladder* (March 10).

5000 −	− 0·0008		− Means from mucous to serous.
+	− off		
+	− 0·0125		
10000 +	− 0·0160		
−	− 0·0020		
−	+ 0·0020	− 0·0100	
+	− 0·0060		

Gall Bladder.

5000 −	+ 0·0066
,, +	− 0·0058
10000 +	− 0·0083
,, −	+ 0·0100

Envelope (March 24).

5000 −	+ 0·0004	The layers were not properly separated
,, +	− 0·0009	
10000 −	+ 0·0010	
,, +	− 0·0025	
,, +	− 0·0025	

B. *Envelope of Gall Bladder.*

5000 +	=	− 0·0045	
10000 +		− 0·0047	First trial of envelope is doubtful as to single layer.
−		+ 0·0018	

Envelope of Gall Bladder (May 7).

5000 +		− 0·0008
−		+ 0·0001

June 7.

Volt.

Electrodes A and B. N.C. = 0. 1/1000 = 9

S.s. 10000 + = 0

„ „ − = 0

Electrodes B and C. N.C. = + 0·0004

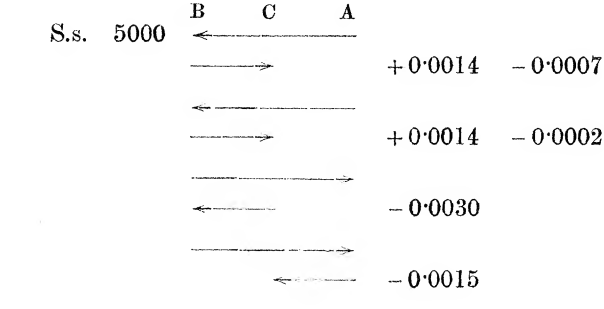
S.s. 10000 + = 0

„ „ − = 0

Gall Bladder.

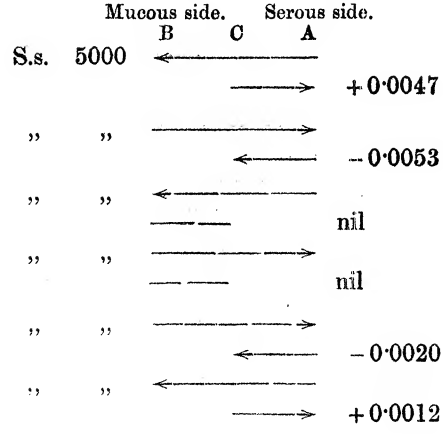
N.C. + 0·0027. B to A.

Shunt $\frac{1}{5}$.	S.s.	5000 +	=	− off	1/100 volt = 14
Shunt $\frac{1}{10}$.	„	„ +	=	− 0·0160	„ = 5
„		−	=	+ 0·0260	
„		1000 −	=	+ 0·0050	
„		+	=	− 0·0043	
Shunt $\frac{1}{5}$.		5000 +	=	− 0·0036	„ = 14
Shunt $\frac{1}{10}$.		10000 +	=	− 0·0071	
		„ −	=	+ 0·0030	



Envelope of Gall Bladder.

S.s. 5000 + = − 0·0020
− = + 0·0030



Gall Bladder—entire (June 10).

S.s.	5000 −	=	+ 0·0075	− 0·0087	
	,, +		− 0·0150	+ 0·0125	
	1000 +		− 0·0020		
	,, −		+ 0·0013		
	5000 −		+ 0·0125	− 0·0110	+ 0·0010
	+		− 0·0100	+ 0·0100	

Portion of envelope only, with electrodes placed one on mucous, the other on serous side.

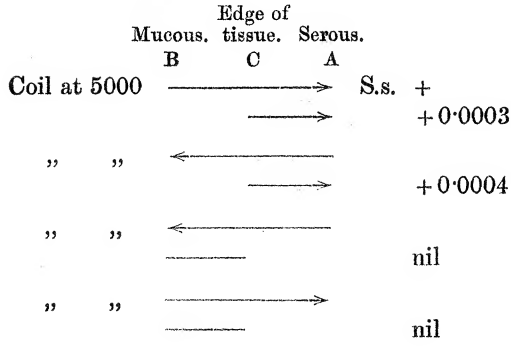
S.s.	5000 −		+ 0·0007	
	,, +		− 0·0031	
	−		+ 0·0012	
	+		− 0·0010	+ 0·0003
	−		+ 0·0015	
	−		+ 0·0015	
	+		− 0·0014	

Slice of Gall Bladder Envelope (July 12).

S.s. coil at 5000 + = − 0·0030
= + 0·0030

Slice of Gall Bladder Envelope (July 14).

S.s.	5000	−	=	+ off scale.
		+	=	+ 0·0008
	10000	+	=	− 0·0009 + 0·0008
	,,	−	=	+ 0·0045
		+	=	− 0·0011 + 0·0003

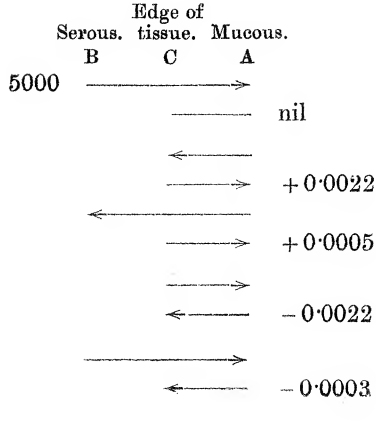


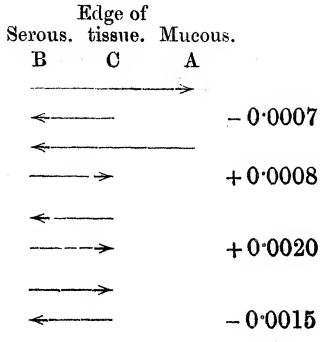
Envelope of Gall Bladder.

5000	−	=	+ 0·0003 − 0·0007
	+	=	− 0·0001
10000	+	=	− 0·0003 + 0·0003
	−	=	+ 0·0010

Envelope (August 3).

5000	−	=	+ 0·0022
	+	=	− 0·0010





Envelope (August 11).

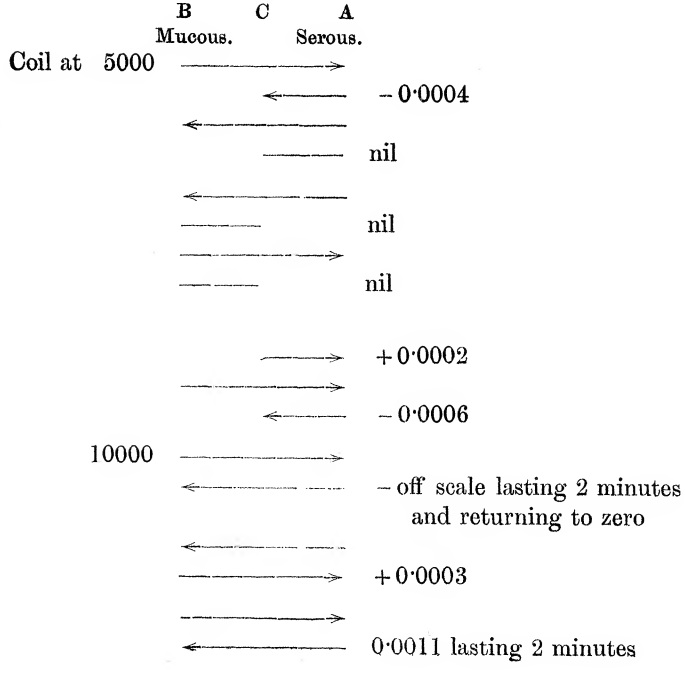
S.s. 5000 – = + 0·0005 Sinking to – 0·0010 and very slowly returning after remaining 2 minutes at – 0·0005

„ + = – 0·0003

10000 + = – 0·0005

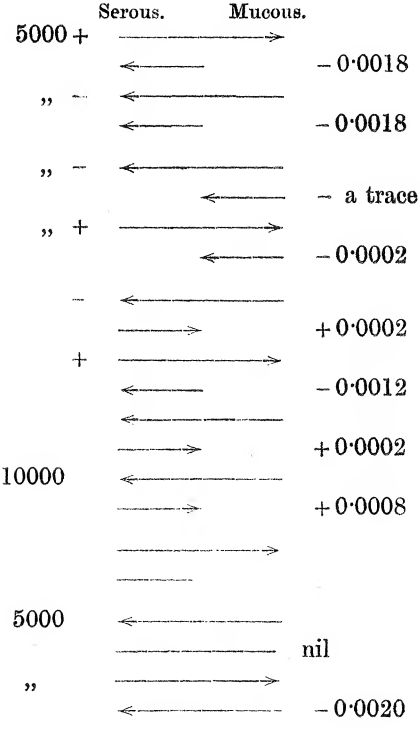
„ – = + 0·0008

Envelope of Gall Bladder.



Envelope of Gall Bladder (July 21).

5000 − = −0·0010 (from mucous to serous)
+ = −0·0020



Slice of Gall Bladder (July 14).

Coil at 5000 − = + off scale
„ + = +0·0008
10000 + = −0·0009 +0·0008
− = +0·0045
+ = −0·0011 +0·0003

In this experiment the envelope was placed so that the + or positive deflection signified a blaze from mucous to serous surfaces. In the five cases given the first is a large effect in the usual antidrome direction, being an addition of the mucous to serous blaze to the negative polarisation characteristic of this tissue, the second is the mucous to serous effect without negative polarisation, the third stimulation being stronger brings out a negative polarisation effect (presumably from the smooth muscle fibres), and then the positive effect from mucous to serous. The last strong stimulation brings out a negative plus the positive effect as in the first case.

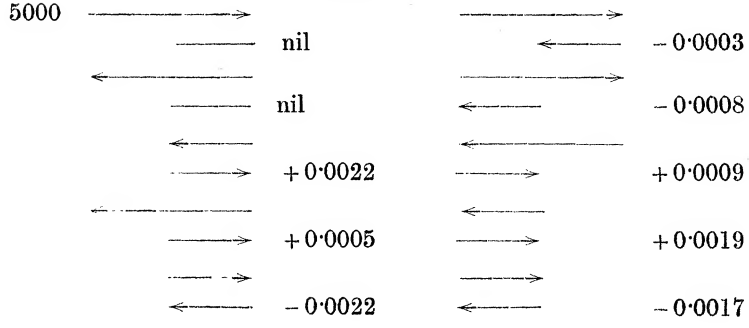
The experiment of July 14 agrees with the experiment of July 21 in that the direction of blaze was from mucous to serous.

The envelope of the gall-bladder behaves like all the mucous membranes in that there is a tendency for the blaze current to pass from mucous to serous tissues, but this effect is constantly masked by the negative or antidrome blaze peculiar to this organ. The ABC method shows that the serous surface displays the antidrome blaze more readily than the mucous surface.

Envelope of Gall Bladder.

Coil at	5000 −	=	+0·0003	−0·0007
	+	=	−0·0001	
	10000 +	=	−0·0003	+0·0003
	−	=	+0·0010	

August 3.



August 11.

Envelope.				*Envelope.*		
5000 +	=	−0·0008		5000 −	=	+0·0005	−0·0009
−	=	+0·0002		+	=	−0·0002	
10000 −	=	+0·0005		10000 +	=	−0·0006	
+	=	−0·0007		−	=	+0·0008	

These experiments show the gall bladder to be an organ whose tissues possess great "chemical lability," the kathode of the single induction shock is more effective than the anode whether the stimulus occurs in the smooth muscle fibres or in the columnar mucous epithelium, so that the blaze is first post kathodic, then post anodic. Occasionally the usual mucous to serous blaze occurs, but of the two components of the structure, the smooth muscle fibres appear to give the blaze current more readily than the columnar epithelium.

The gall bladder presents a very striking instance of the equivocal or antidrome blaze current.

In conclusion I should like to be allowed the pleasure of thanking my husband for continual help and sympathy in my work, and to record my appreciation of and gratitude for the method of investigation, and simplified arrangement of electrical apparatus which renders it easy to study the many fascinating problems of animal and vegetable electricity.

On the Compressibility of Gases between One Atmosphere and Half an Atmosphere of Pressure." By Lord Rayleigh, O.M., F.R.S. Received January 17,—Read February 2, 1905.

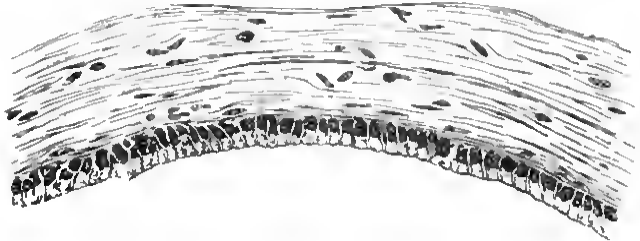
(Abstract.)

The present memoir contains a detailed account of the observations referred to in the Preliminary Notice of February, 1904. In addition, results are now given for air, carbonic anhydride, and nitrous oxide. In the following table are recorded the values of B for the various gases at specified temperatures, B denoting the quotient of the value of pv at half an atmosphere by the value at the whole atmosphere:—

Gas.	B.	Temperature.
Oxygen	1·00038	11·2
Hydrogen	0·99974	10·7
Nitrogen	1·00015	14·9
Carbonic oxide	1·00026	13·8
Air	1·00023	11·4
Carbon dioxide	1·00279	15·0
Nitrous oxide	1·00327	11·0

By means of a formula given by D. Berthelot the compressibilities at 0° C. are inferred, and applied to deduce the ratio of densities as they would be observed at 0° C. under very low pressures. According to Avogadro's law these are the relative molecular weights. From the densities of nitrogen and oxygen we get N = 14·008, if O = 16. Again, from the densities of oxygen and nitrous oxide we find N = 13·998. The former is probably the more trustworthy.

FIG. 3.



Section of Frog's Gall Bladder, showing Inner Mucous Layer of Columnar Epithelium, and Outer Layers of Smooth Muscle Fibres. (Enlarged 2500 diameters and Photographed by Mr. H. Gordon Webb, Assistant Demonstrator of Anatomy in St. George's Hospital Medical School.)